SIXTEENTH ANNUAL

REPORT

—OF—

Rutgers Scientific School,

THE STATE COLLEGE,

—FOR THE—

BENEFIT OF AGRICULTURE AND MECHANIC ARTS,

New Brunswick, N. J.,

FOR THE YEAR 1880.

ORANGE, N. J.:
Samuel Toombs, Printer,
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BOARD OF VISITORS.

	Residences.	Terms Expire.
FIRST CONGRESSIONAL DISTRICT.		
Hon. THOMAS H. DUDLEY,	Camden,	April 12, 1882.
WOODWARD WARRICK, Esq.,	Glassboro,	April 12, 1882.
SECOND CONGRESSIONAL DISTRICT.		
Hon. WILLIAM PARRY,	Cinnaminson,	April 12, 1881.
WILLIAM S. TAYLOR, Esq.,	Burlington,	April 12, 1882.
THIRD CONGRESSIONAL DISTRICT.		
Hon. WILLIAM A. NEWELL,	Allentown,	April 12, 1882.
JAMES NEILSON, Esq.,	New Bruns'k,	April 12, 1882.
FOURTH CONGRESSIONAL DISTRICT.		
JOHN DeMOTT, Esq.,	Middlebush,	April 12, 1881.
WM. R. JANEWAY, Esq.,	Franklin Tp.,	April 12, 1882.
FIFTH CONGRESSIONAL DISTRICT.		
WILLIAM HILLARD, Esq.,	Peapack,	April 12, 1882.
NATHAN H. DRAKE, Esq.,	Flanders,	April 12, 1882.
SIXTH CONGRESSIONAL DISTRICT.		
PATRICK T. QUINN, Esq.,	Newark,	April 12, 1882.
WILLIAM M. FORCE, Esq.,	Newark,	April 12, 1881.
SEVENTH CONGRESSIONAL DISTRICT.		
ABRAHAM W. DURYEE, Esq.,	New Durham,	April 12, 1882.
Hon. ORESTES CLEVELAND,	Jersey City,	April 12, 1882.

OFFICERS:

Hon. WILLIAM PARRY, *Chairman.*
GEORGE H. COOK, *Secretary.*

REPORT OF STATE BOARD OF VISITORS.

To His Excellency Geo. B. McClellan, Governor of the State of New Jersey :

HONORED SIR—The Board of Visitors of the State Agricultural College herewith present their sixteenth annual report of the present condition and course of instruction in the College, as required in the act creating the Board, entitled "An act appropriating script for lands granted to the State of New Jersey by the act of Congress approved July 2d, 1862," and approved April 4, 1864.

Two meetings of the Board have been held at the College during the year for the purpose of attending the examinations of the students, and committees of the Board have also visited the College farm and examined the work and experiments in progress there.

The first meeting of the board was held on the 18th of December, 1879.

Present : Hon. William Parry, President ; and Messrs. DeMott, Dudley, Duryee, Albertson and Neilson.

The examinations attended by the members were as follows :

Seniors in Organic Chemistry, by Prof. Cook.
Juniors in Analytical Geometry, by Prof. Bowser.
Juniors in Political Economy, by Prof. Atherton.
Sophomores in Land Surveying, by Prof. Bowser.
Sophomores in Descriptive Geometry, by Prof. Hasbrouck.
Freshmen in Physiology and Zoology, by Prof. Van Dyck.

All the classes were examined in Analytical Chemistry by Prof. Austen.

All the classes have been taught Draughting by Prof. Hasbrouck, and their drawings were examined.

After the examinations were ended, the Board met to compare their notes, and to discuss the merits of the course of instruction and the attainments of the students therein. After a very free and full interchange of views, and expression of opinion by each of the members present, the following resolution was unanimously adopted, viz.:

That we, the Board of Visitors of Rutgers Scientific School, on behalf of the State of New Jersey, having visited the various lecture-rooms, and places prepared for the students' study and practice, and having heard all the classes examined in the branches of learning they are now studying, do hereby express our satisfaction with the provisions made for the instruction of the students, our approval of the branches of learning laid out to be taught in the several courses of study, and our judgment that they are well and thoroughly taught. And we further express to the people of the State our conclusion that the Trustees of Rutgers College are fulfilling their responsibilities to the State in the most liberal and useful manner.

The course of instruction in Agriculture for two years' study was brought to the special attention of the Board, and after careful examination it was

Resolved, That the Board approve of the course of instruction which the Faculty and Trustees of Rutgers College have adopted for students who wish to pursue branches of learning specially relating to Agriculture, and commend it to the people of the State.

The Board also took up the question relating to the establishment of an Agricultural Experiment Station, and considering that this institution as well as this Board have, somewhat, in their charge the interests of agriculture in New Jersey, it was resolved that a committee of the whole Board be appointed to memorialize the Legislature upon the subject and to ask for the establishment of such a station in connection with the farm of the College. The Board then adjourned.

The SECOND MEETING was held at the College to attend the summer examination of the students, on June 16, 1880. There were present, Hon. William Parry, President; and Messrs. DeMott, Duryee, Janeway, Neilson, Newell, Taylor and Warrick.

Examinations were attended as follows, viz.:

Juniors in Astronomy—Prof. Merriman.

Juniors in Analytical Chemistry—Prof. Austen.

Juniors in German—Prof. Meyer.

Sophomores in Descriptive Geometry—Prof. Hasbrouck.

Sophomores in Railroad Curves—Prof. Bowser.

Sophomores in Constitutional History of England—Prof. Atherton.

Freshmen in Botany—Prof. Van Dyck.

Freshmen in French—Prof. Meyer.

Drawings executed by members of each of the classes were also shown by Prof. Hasbrouck. These were read by members of the graduating class, as follows:

The Analysis of Spiegel-eisen, by Chas. M. Freeman, Metuchen.

An Examination of Kerosene Oils, by Frank A. Chapman, of Madison.

An Examination of Sugars sold in New Brunswick, by Wm. D. Schoonmaker, of Stone Ridge, N. Y.

At the meeting of the Board after the close of the examinations, the several members discussed the items of business to which they had attended and passed a resolution expressing their high appreciation of the educational attainments of the students, their approval of the course of study pursued, and their satisfaction with the liberal manner in which the Trustees of Rutgers College are filling their contract with the State. The Secretary of the Board submitted to them a circular he had prepared, giving an account of the free scholarships in the Institution, which belong to the several counties of the State, the courses of study open to students, the practical bearing of the studies pursued, the benefits students have already derived from them, and the course to be taken by those who wish to become students and enjoy the privileges these scholarships bring.

The paper was approved and the Secretary was directed to give it as wide a circulation in the State as possible.

It was reported that the application to the Legislature for the establishment of an Agricultural Experiment Station was successful and that a law had been passed establishing such a station, appropriating $5,000 a year for its support, and appointing the Governor of the State, the President of the Agricultural College, the Professor of Agriculture, and the Board of Visitors of the College, directors of the station. It was also reported that the Directors had organized as a Board and had located the station at New Brunswick, and that the Trustees of Rutgers College had provided them with rooms for an office and a laboratory in the College building.

Messrs. DeMott, Duryee, Janeway and Neilson reported that they in company with Mr. Dudley had visited the College farm, had examined various interesting experiments in progress, and were of the opinion that it was filling an important place in the improvement of agriculture in New Jersey.

It was reported to the Board that since its last meeting the Hon. Chalkley Albertson, one of its active and efficient members, had died. He had been a member of the Board of Visitors since 1873. He was a constant attendant at its meetings, and always took a hearty interest in the scientific school and its objects. Almost the last public business he had attended to was that at Trenton, with the members of this Board, presenting the claims of the Agricultural Experiment Station, and urging its establishment. We desire to record his useful course while with us, our personal esteem for him, and our sorrow at his loss.

The meetings of the Board, the examinations of the young men and the visit to the laboratory, museum and working rooms, give us a vivid perception of the great benefits to educated industry which the course of study here offers. There are hundreds of young men in New Jersey to whom the education acquired in this institution would be a fortune. Since the last meeting of the Board we have done what we could to bring the advantages of the College to the attention of our young men. A larger number of students have come in this year than in any former year—there being only 22 last year, while there are now 34 students on county scholarships—and there is a thorough waking up of the people in regard to it in some of the counties. In other counties, however, there is no apparent interest in the subject. There are five counties from which no students have been sent. A careful reading of the Trustees' report in all its parts, will, we think, convince any unprejudiced person that there are branches of learning taught in this school which should find profitable application in practical industry, whether it be in farming, mechanics, manufacturing, trading or professional life. The establishment of the Agricultural Experiment Station at the College has added a new link between science and practical farming in New Jersey which is awakening a lively interest in all parts of the State.

The members of the Board or their Secretary are ready at all times to furnish information in regard to the College and the opportunities it offers for acquiring a thorough scientific education.

All of which is respectfully submitted.

WILLIAM PARRY, *President.*

TRUSTEES' REPORT.

RUTGERS COLLEGE,
NEW BRUNSWICK, December 1, 1880.

To His Excellency George B. McClellan, Governor of the State of New Jersey:

SIR—In compliance with the act of Congress, approved July 2d, 1862, and the act of the Legislature of New Jersey, approved April 4th, 1864, I beg leave to submit, on behalf of the Trustees of Rutgers College, the sixteenth annual report of Rutgers Scientific School.

I. THE FACULTY.

The Faculty of the Institution remains the same as at the date of the last annual report, and is now constituted as follows:

Rev. Wm. H. Campbell, D. D., LL. D., President, and Professor of Moral Philosophy.

George H. Cook, Ph. D., LL. D., Vice-President, and Professor of Geology and Agriculture.

Rev. Theodore S. Doolittle, D. D., Professor of Rhetoric, Logic and Mental Philosophy.

John C. Smock, A. M., Professor of Mining and Metallurgy.

George W. Atherton, A. M., Professor of History, Political Economy and Constitutional Law.

Rev. Carl Meyer, D. D., Professor of French and German.

Francis C. Van Dyck, A. M., Professor of Inorganic Chemistry and Physics.

Edward A. Bowser, M. S., C. E., Professor of Mathematics and Engineering.

Isaac E. Hasbrouck, A. M., Professor of Mathematics and Graphics.

George B. Merriman, A. M., Professor of Mathematics, Astronomy, and Experimental Mechanics.

Peter Townsend Austen, Ph. D., F. C. S., Professor of Analytical and Applied Chemistry.

Francis A. Wilber, B. S., Assistant in Analytical Chemistry.

II. COURSES OF STUDY AND DEGREES.

The courses of study in the Scientific School are as follows :

1. *A course of four years in Civil Engineering and Mechanics.*
2. *A course of four years in Chemistry and Agriculture.*
3. *A special course of two years in Chemistry.*
4. *A special course of two years in Agriculture.*
5. *Post-Graduate courses.*

The SPECIAL COURSE in Chemistry is intended for the convenience of students who wish to devote themselves exclusively to that branch of study. Greatly increased facilities have recently been provided for them in the Laboratory and Lecture-rooms, allowing the full employment of their time. On completing the course, they receive a special diploma.

Provision is also made for PARTIAL STUDENTS, who may enter at any time, and elect, under the advice and direction of the Faculty, such studies as they may be found qualified to pursue, with classes already formed. Such students are subject to the general regulations and discipline of the Institution. They are required to have their time fully occupied, and to pass such examinations as may be prescribed in each case. On leaving, they receive certificates stating the studies pursued and the amount of work performed in each.

The two principal courses cover a period of four years each. The studies for the first two years are the same in both courses, and are arranged with special reference to the wants of young men who desire to fit themselves to become land-surveyers, or to enter any department of skilled industry, but are unable to remain four years in the Institution. Students who leave at the end of this short course receive certificates.

At the end of the two years' course, students elect whether to pursue the course in Civil Engineering and Mechanics, or that in Chemistry and Agriculture, and for the remaining two years their studies are directed with particular reference to the choice made. Some studies, however, of a general nature, such as History, English Literature, Political Economy, Moral Philosophy and others, are interspersed throughout the entire four years, in order that students may not only acquire a thorough preparation for their special pursuits in life, but may at the same time receive a liberal training which will fit them to discharge wisely and usefully the duties of good citizenship.

Students completing either of the four years' courses, receive the degree of Bachelor of Science.

Heretofore, the degree of Master of Science has been conferred, in course, upon all graduates of three years' standing. The Trustees have long been convinced that the practice of conferring high academical honors, indiscriminately, without regard to the character or attainments of those who receive them, is an unfair discrimination against those who have honorably earned recognition, and calculated to bring all such marks of distinction into undeserved discredit. They have accordingly decided to confer no degrees "in course," after the Commencement in 1881, and they regard this as an important step in the direction of maintaining a high standard of scholarship.

The degrees of Civil Engineer and Doctor of Philosophy are conferred for distinguished professional or practical success, or, on examination, in prescribed subjects.

A schedule of the several courses of study accompanies this report.

III. POST-GRADUATE STUDIES.

In addition to these courses of study for the under-graduates, several post-graduate courses have been arranged (and the number will be increased as occasion requires), for students who desire, after graduation, to pursue special lines of training and research.

In Chemistry, students can pursue special studies and investigations in the Analytical Laboratory, under the direction of a professor, upon subjects connected with industrial or professional life.

In Geology and Natural History, the large collections in Geological Hall are available for extended courses of study, and can be used, under the direction of a professor, for special study in Geology, Mining, Metallurgy, and the various branches of Engineering.

In Agriculture, the well-equipped farm and laboratories give unusual opportunities for advanced studies in this department, and every facility is afforded for their use.

In Mathematics, instruction will be given in any of the following subjects: Geodesy, with practice ; Higher Mathematics (pure) ; Theoretical and Practical Astronomy ; the use of Physical Apparatus.

In Modern Languages, the course will include Lectures on French Literature, Lectures on German Literature, Lectures on German Etymology, on German Mythology, and on the Phonology and Morphology of the Indo-Germanic Languages, as bearing on German.

In the Department of Political and Social Science, provision is made for instruction in an advanced course in Political Economy; in the Constitutional History and Jurisprudence of the United States; in the History of the English Constitution; and in the elements of Roman Law.

These various subjects, according to the choice of students, will be arranged in courses of one, two or three years.

Students completing a full course of two years, in any two of the departments, will be entitled to the degree of Bachelor of Philosophy.

Students completing a full course of three years, in any three of the departments, will be entitled to the degree of Doctor of Philosophy.

IV. TERMS OF ADMISSION.

The conditions of admission to the regular courses of study and to the Special Course in Chemistry have recently been somewhat increased, and are now as follows:

Applicants must be sixteen years of age, and of good moral character; and, if they come from other institutions, must bring a certificate of honorable dismission. They are required to pass a satisfactory examination in English Grammar and Spelling, Descriptive Geography, Physical Geography, History of the United States, Arithmetic, including the Metric System, Algebra to Series, and the whole of Plane Geometry.

The regular examinations for admission to the Freshman Class are held on the Friday and Saturday preceding the annual commencement, and on the day before the opening of the fall term. Candidates for advanced standing are examined in the preparatory studies, and in those already pursued by the class which they propose to enter.

V. STUDENTS.

Of the four classes now in the institution, which will be graduated in June, 1881, 1882, 1883 and 1884, respectively, the Senior Class consists of ten students, the Junior Class of seven, the Sophomore Class of four, and the Freshmen Class of seventeen. There are also thirteen special students, making a total of fifty-one now in attendance.

There have been in the institution, during the year, fifty-seven students, of whom one was from Scotland, one from the State of Pennsylvania, seven from the State of New York, and the remaining forty-seven from the State of New Jersey, representing thirteen counties, as follows :

Burlington,	1	Middlesex,	12
Cape May,	1	Monmouth,	8
Essex,	8	Morris,	1
Gloucester,	2	Passaic,	1
Hudson,	2	Somerset,	4
Hunterdon,	1	Union,	3
Mercer,	2	Warren,	1

Under the law of New Jersey, designating this institution as "The State College for the Benefit of Agriculture and the Mechanic Arts," forty students from this State are entitled to free tuition for the entire course. These students are admitted on the recommendation of the Superintendent of Schools in each county, and are distributed among the counties in proportion to their representation in the Legislature, as follows :

Atlantic,	1	Middlesex,	2
Bergen,	1	Monmouth,	2
Burlington,	3	Morris,	2
Camden	2	Ocean	1
Cape May,	1	Passaic,	2
Cumberland,	1	Salem,	1
Essex,	6	Somerset,	1
Gloucester,	1	Sussex,	1
Hudson,	6	Union,	2
Hunterdon,	1	Warren,	1
Mercer,	2		

In filing these State scholarships the Trustees have, from the first, adopted the most liberal interpretation of the law ; and, in fact, have gone far beyond its requirements, as the following statement, repeated from a former report, will indicate :

"In cases where the scholarship is not filed by the county entitled to it, the Trustees have adopted the policy of allowing it to be filled temporarily, with the consent of the County Superintendent, by an applicant from some other county ; and, in general, tuition is habitually remitted to students who are unable to pay that in addition to the other expenses of procuring an education."

The following tables, which have been prepared with great care by Professor Hasbrouck, present, in a condensed form, a complete exhibit of what has been done in the way of furnishing free tuition, since the institution was organized, together with a summary of attendance, by years and by counties :

I.—Table Showing the Number of Students from each County at the present time, and their relation as to tuition.

COUNTIES.	Scholarships.	ON SCHOLARSHIP.			Free.	Pay.	Total
		By appointment.	By transfer.	Transferred to other Counties.			
Atlantic	1		1				
Bergen	1		1				
Burlington	3	1	1				1
Camden	2		1				
Cape May	1	1					1
Cumberland	1						
Essex	6	6					8
Gloucester	1	2		1	3		2
Hudson	6	1	5				1
Hunterdon	1	1					1
Mercer	2	2					2
Middlesex	2	5		3	1	3	9
Monmouth	2	4		2	2		6
Morris	2	1					1
Ocean	1	1					1
Passaic	2	1					1
Salem	1						
Somerset	1	2		1			2
Sussex	1						
Union	2	4		2			4
Warren	1	1					1
Totals, New Jersey	40	33	9	9	4	3	41
Other States							9
Grand Total							50

II.—Table Showing the Number of Students from each County, from the beginning, and their relation as to tuition.

COUNTIES.	Scholarships.	ON SCHOLARSHIP.			Free.	Pay.	Counted twice.	Total
		By appointment.	By transfer.	Transferred to other Counties.				
Atlantic	1		1		1			1
Bergen	1	2	1		2			4
Burlington	3	1	3					1
Camden	2	1	2					1
Cape May	1	1	1					1
Cumberland	1	2		1	1			3
Essex	6	18	4		8	2		28
Gloucester	1	4		1				4
Hudson	6	4	7		2	2		8
Hunterdon	1	3						3
Mercer	2	6			4		1	9
Middlesex	2	14		9	28	28		70
Monmouth	2	10		3	5	1		17
Morris	2	11		2	2	2	1	14
Ocean	1	3						3
Passaic	2	2			1			3
Salem	1		1					
Somerset	1	6		2	8	3		17
Sussex	1	1			1			2
Union	2	11		2	7	6		24
Warren	1	1						1
	40	101	20	20	70	44	2	214
Other States								63
Grand Total								277

III.—Table showing the Relation of Students as to Tuition for each Collegiate Year from the Beginning.

COLLEGIATE YEARS.	NEW JERSEY.				Other States.	Grand Total.
	On Scholarship.	Free.	Pay.	Total.		
1865–66	1	2	2	5	2	7
1866–67	8	7	5	20	3	23
1867–68	13	17	7	37	6	43
1868–69	17	10	4	31	7	38
1869–70	15	13	3	31	5	36
1870–71	20	11	8	39	10	49
1871–72	18	15	7	40	14	54
1872–73	17	9	7	33	11	44
1873–74	14	15	5	34	14	48
1874–75	12	13	9	34	14	48
1875–76	15	13	8	36	9	45
1876–77	17	15	5	37	6	43
1877–78	14	12	6	32	7	39
1878–79	20	5	8	33	5	38
1879–80	24	8	3	35	7	42
1880–81	33	5	3	41	9	50

IV.—Table showing the Number of Students Present by Counties, from the Beginning, for each Collegiate Year.

COUNTIES.	Scholarships.	COLLEGIATE YEARS.															
		1865-66.	1866-67.	1867-68.	1868-69.	1869-70.	1870-71.	1871-72.	1872-73.	1873-74.	1874-75.	1875-76.	1876-77.	1877-78.	1878-79.	1879-80.	1880-81.
Atlantic	1	--	----	----	----	----	----	----	1	1	1	1	----	----	----	----	----
Bergen	1	--	----	----	1	----	2	1	----	----	----	1	1	----	----	----	----
Burlington	3	--	----	----	----	----	----	----	----	----	----	----	----	----	----	----	1
Camden	2	--	----	----	----	----	----	----	1	----	----	----	----	----	----	----	----
Cape May	1	--	----	----	----	----	----	----	----	----	----	----	----	----	1	1	1
Cumberland	1	--	1	1	----	2	2	2	----	----	----	----	----	----	----	----	----
Essex	6	2	2	3	5	6	6	3	2	1	3	4	2	1	----	3	8
Gloucester	1	--	----	----	----	----	1	1	1	1	1	----	----	----	----	1	2
Hudson	6	--	----	----	----	----	1	4	4	3	2	----	----	1	1	2	1
Hunterdon	1	--	----	----	----	----	----	1	1	1	1	1	1	----	1	1	1
Mercer	2	--	2	5	2	3	1	1	----	1	1	1	1	----	1	2	2
Middlesex	2	--	6	13	9	7	9	7	10	14	17	16	17	16	15	15	9
Monmouth	2	--	2	4	4	4	2	1	----	1	1	1	2	4	4	3	6
Morris	2	--	1	1	1	3	4	5	3	2	2	1	2	3	4	3	1
Ocean	1	--	----	----	----	----	----	1	1	1	----	----	----	----	1	1	1
Passaic	2	--	1	1	1	----	----	----	----	1	1	1	1	----	1	1	1
Salem	1	--	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Somerset	1	1	3	6	6	4	4	5	3	1	----	----	----	1	2	2	2
Sussex	1	1	1	----	----	----	----	----	----	----	----	1	1	1	----	----	----
Union	2	1	1	3	2	2	7	8	6	6	6	8	8	4	1	----	4
Warren	1	--	----	----	----	----	----	----	----	----	----	----	1	1	1	----	1
Totals, New Jersey	40	5	20	37	31	31	59	40	33	34	34	36	37	32	33	35	41
Other States	--	2	3	6	7	5	10	14	11	14	14	9	6	7	5	7	9
Grand Totals	--	7	23	43	38	36	49	54	44	48	48	45	43	39	38	42	50

V.—Table showing the Occupation of 92 *of the Students of Rutgers Scientific School who have Graduated, and of* 54 *who have left without Graduating, from the beginning to September,* 1879, *inclusive, these being the only ones whose occupation is certainly known.*

STUDENTS.	OCCUPATIONS.								
	Eng'r	Arch't	Mf'r	F'mr	M. D.	Law'r	T'ch'r	Busin's	Student
Who graduated	38	3	13	6	6	8	9	7	2
Per cent	41	3	14	6.5	6.5	9	10	8	2
Who did not graduate	5	2	6	10	4	3	4	20	--
Per cent	9	4	11	19	7	6	7	37	--
Totals	43	5	19	16	10	11	13	27	2
Per cent	29	3	13	11	7	8	9	18	1

VI. SPECIAL DEPARTMENTS.

The method and scope of work in the several departments of the institution have undergone no particular change since the date of the last report, though it is but just to the gentlemen in charge to say that that there are in each department gratifying indications of steady and vigorous growth.

I. MATHEMATICS.

In this course, during the first two years, students are instructed in Algebra, Geometry, Trigonometry, Descriptive Geometry, Surveying, Railroad Curves, &c., and receive sufficient field practice to make them able to survey farms, either with the compass or the transit, and to determine the magnetic variations. Those who take the Engineering Course for the full term of four years, are instructed in Analytic Geometry, Calculus, Mechanics, Civil Engineering, Bridge Building, Geodesy, &c., having at the same time daily practice in Draughting. In Geodesy, the students receive instruction in making a *reconnoissänce* survey for a projected triangulation system, the measurement of the base-line with its several reductions, erection of signals, measurement of horizontal angles and their adjustment by the "Method of Least Squares," computation of latitudes, longitudes and azimuths, &c. For the past six years some of the students of this department have been employed on the Geodetic Survey of New Jersey, with good results. The aim of the instruction is to give the students clear ideas of the elements of the higher mathematics and a knowledge of the theory of Engineering, so that after graduation they may be able to pursue, understandingly and continuously, an advanced course of mathematical study, or to go into the field or the office as engineer's assistants, and do good, useful work. This course does not aim to make practical engineers, but to lay a foundation of sound theory on which alone practical success can be assured.

II. GRAPHICS.

During the past year instruction in Descriptive Geometry has been given the Sophomore Class. A text book was used in the recitation-room as a convenient method of bringing principles to the students' attention, and of discussing them. At the same time, problems prepared by the Professor, and furnishing novel and practical applications of these principles, were assigned for solution in the draughting-room. These have proved of very great benefit not only in giving a meaning to what might otherwise have seemed abstractions, but in familiarizing the mind with the relations and properties of Geometrical magnitudes, and with the many artifices of solution which are invaluable to the Draughtsman as well as to the Descriptive Geometer. The work of the year in this respect has been exceptionally satisfactory; the problems solved being more numerous and more difficult than those of previous years, and the solutions furnished possessing unusual merit in originality of method as well as in comprehension of principles. Many of the problems were more difficult than those assigned for the "Science Examinations" in England. The subjects of the Intersection of Surfaces, Shades and Shadows and Linear Perspective were illustrated by problems which stimulated investigation and ingenuity on the part of the student. At the end of the year the growth in the power of synthetic and analytic reasoning was felt by the students themselves, as it was evident to the Professor.

Instruction to the other classes was entirely oral, in connection with work at the draughting-table. During the hours devoted to this work, questions and discussions either among the students themselves or with the Professor, are always in order, and generally in progress. As a result, not only are methods learned, but also the reasons for them, with the occasion and effects of modifications. From this comes a more thorough mastery of the principles and a greater facility in their application. In short, the student grows into an intelligent and ready draughtsman. The work with these classes was in the construction of Geometrical problems, topographical drawing, lettering, the use of colors and practice in shading, cutting of timbers, finished drawings, etc.

As our students are preparing for various and dissimilar vocations, the arrangement of special courses in drawing with reference to such vocations is not to any great extent practicable. But, although we can give but little more than an introduction to a few of the applications of drawing, yet in doing this, much is accomplished in the education of the student. He acquires the elements of a new language, the only one which knows no distinction of race, clime, or epoch, in which the people of centuries past have handed down to us their records, otherwise incomprehensible, and which may properly be designated the Universal Language. He can comprehend to some extent the meaning and requirements of practical questions in drawing, and can bring into use the necessary means to secure the end desired. In the office of the engineer or architect, he has sufficient familiarity with methods and readiness in execution to assure him at the outset a position of respect if not of great responsibility; to enable him to grow more rapidly and surely in the principles and practice of his profession, and more successfully and fully to respond to such demand as may be made upon him. If we do not prepare students to take at once the superintendency of a pattern-shop, or to undertake the designing of a locomotive, or the preparation of the plans for a cathedral or a man-of-war, we can at least equip them with knowledge and skill sufficient to render them valuable assistants to the mechanical or civil engineer, to the house or naval architect, and can give them the foundation on which to build, from their observation and experience, a comely and safe professional superstructure. Though the student enter none of these callings, the training in drawing is invaluable. Readiness and accuracy in expressing ideas and facts by drawing is of great assistance everywhere. Besides, there is the training of the eye, of the hand and of the mind, to quickness of perception, deftness of execution and promptness of recognition and resolution of relations and conditions, which could be obtained from few other exercises.

Attention has been called in previous reports to the great hindrance to the most effective work in this department, arising from the fact that very rarely does any new student coming here, except from the Rutgers College Grammar School, have even the most elementary knowledge of right line drawing. The names of the most common draughting instruments are entirely unknown to him. Of course he knows nothing of their purposes or of the manner of using them for the simplest operations. Again would we protest to the people of the State against this unnecessary waste of time—in the curriculum and to the student—a waste which is the more to be lamented because occurring when opportunities afforded for advanced instruction, based upon the principles of mathematics and mechanics here taught, cannot be improved by reason of a want of elementary instruction in this subject. The possibilities of at least one year are lost from this cause. Besides, a few of the students, as indicated above, having had some instruction in elementary drawing, must either repeat the course or a difficulty arises in providing proper work and oversight for different members of the same class, which cannot be well met without increased teaching force and facilities. We feel interested in this question as an institution, for students coming to us are not ready to receive for themselves, and prevent the giving to others who are ready, the instruction which we could and desire to furnish ; and we are thus hindered from accomplishing the full measure of results which we feel we might otherwise attain.

It seems proper that schools established for the encouragement of Agriculture and the Mechanic Arts, of which this is one, should encourage the art of drawing, particularly industrial drawing ; and that it should use its influence to secure the recognition of this branch as of equal importance with the three R.'s ; for, as Your Excellency recognized in a recent message, "drawing, as applied to the arts and trades, is the basis which underlies the vast majority of the pursuits of our people, and can be profitably made a part of the course in our public schools." For reasons suggested in a previous paragraph, training in drawing would be of great benefit to the pupils of our public schools, though they never became architects or engineers or even draughtsmen. But, further, practice in drawing assists to facility and elegance in writing. This has been demonstrated by the experience of the Prussian Schools as reported by Horace Mann ; by an experiment introduced by Rembrandt Peale into the schools of Philadelphia in 1847 ; and by another, made in the schools of London in 1851. In addition, the knowledge of drawing was entire gain, and the experiment showed that all who could learn to write could learn to draw.

The demand is to-day more imperative than ever before for the best training in every department not only, but for training in what will best fit for successful labor. The principle of the survival of the fittest is no more true in natural history than in economies. In the great competitions between manufacturers, into which they are forced by the operation of natural laws, it is coming to be recognized that profits must come from savings. He who employs the best machinery and the best processes with the most intelligent labor to direct them, will save most, will therefore succeed best. But how are all these niceties of arrangement and of adjustment to be provided for? Through the machine-shop and the laboratory. Here drawings are needed, for experience has shown that to be well made almost everything must be made from drawings. If the necessity for a knowledge of drawing is so constant and so general, some provision should be made to supply it, for not only must we have skill to make drawings, but technical intelligence and skill to interpret them when made. Our industries need laborers with the knowledge which helps work and hinders waste; who, seeing in the drawing which guides them a complete representation of the end to be accomplished, need less superintendence, work more rapidly, fit parts more neatly and accurately, waste less material, and give more value to their products; artisans as well as artists.

There are few States in the Union in which the subject of Industrial Drawing is so important as in New Jersey. Her varied industries make constant demand upon the designer and the draughtsman. The Department of Graphics in this "School for the encouragement of Agriculture and the Mechanic Arts" aims to help supply that demand.

III. ASTRONOMY.

The Daniel S. Schanck Observatory is a two-story brick building, with revolving dome, constructed especially for astronomical work. It contains in the main part the equatorial telescope, mounted on a pier of solid masonry extending several feet below the surface of the ground, and detached from the floors, through which it rises, so as to be unaffected by the tremors of the building. The telescope is eight feet four inches in focal length, with an aperture of six and one-half inches, and was made by the late Henry Fitz of New York. It has a small telescope attached for a finder, a driving clock, a position micrometer, a number of eye pieces (two of superior quality having been recently added), a prism and glasses for solar observations. The declination circle is ten inches in diameter, reading by verniers to one minute of arc, and the hour circle, seven and one-half inches in diameter, reads by verniers to six seconds of time.

On the west side of the main part is an extension for transit observations. The meridian circle used for this work was made by Stackpole & Brother of New York, and has an object-glass four inches in diameter and four feet ten inches in focal length, with circles seventeen inches in diameter, reading by two microscopes with micrometer screens to single seconds of arc. The diaphragm carries one horizontal and nine vertical wires. There is also a striding spirit-level and an apparatus for reversing the axis of the instrument. The bearings rest on two stone pillars supported by piers of masonry.

The Observatory has also a sidereal clock, by Wm. Bond & Son, the gift of John Clark, Esq., of New Brunswick, with an electrical break-circuit; a mean solar clock, the gift of the Piethessophian Society of Rutgers College, and a reflecting circle, the gift of the Philoclean Society of Rutgers College, and a chronograph loaned to the Observatory by the Superintendent of the U. S. Coast Survey.

The Observatory is in connection with the Washington Observatory by telegraph, and during the past year a series of observations in connection with observations at Washington have been made for determining the longitude of the Observatory. The final result is not yet obtained.

The instruments are all in good working condition, and the student of practical astronomy has here every facility for learning the methods of astronomical observation. Practice is acquired in observing transits both by the "eye and ear" method, and by chronographic signals, and also in making differential measurements with the micrometer.

A familiarity with the refined methods of measurement which astronomical instruments afford, and the habit of thinking for one's self which the use of such instruments helps to form, are in themselves no small means of mental culture. Add to this the familiar acquaintance with the elements of spherical astronomy and the useful methods of computation which the practical study of this most perfect of the sciences imparts, and the advantage and satisfaction to the student are readily manifest.

The elements of Astronomy are taught by the use of a text-book and by lectures four times a week during the last term of the junior year. Those who elect a special course in Astronomy receive further instruction three times a week through the senior year, learning the use of the instruments and taking part in the observations. Post-graduate students can take a still more extended course. Among the subjects included in the course are the following:

Theory and use of the instruments.
Determination of instrumental errors.
Determination of sidereal, apparent and mean solar time.
Transformation of different systems of co-ordinates.
Reduction of observations for refraction and parallax.
Determination of latitude and longitude.
Reduction of stars from apparent to mean place, and *vice versa.*
Theory of interpolation.
Combination of observations by the method of least squares.
Calculation and projection of eclipses.
Calculation of ephermerides.
Calculation of the orbits of comets and planets.

As part of the work done the past year by the class in Elective Astronomy may be mentioned, the more perfect adjustment of the equatorial telescope; the construction of tables adapted to the latitude of the Observatory to facilitate the reduction of instrumental errors of meridian observations; the reduction by the method of least squares of a part of the observations for longitude; the calculation and projection of a solar eclipse;—besides various miscellaneous observations. The work done by them was very creditable both in quantity and quality.

IV. PHYSICS.

Instruction is given in Mechanics, Sound and Light, four times a week during the first two terms of the Junior Year. "Deschanel's Natural Philosophy" is used as a text-book, but is largely supplemented with lectures, explanations and problems. The subjects are treated both experimentally and theoretically. The students are required to take notes of the lectures and experiments, and of the solution of exercises, and these notes are at intervals inspected by the instructor.

The Mechanics included in the first part of this course serves not only as a good preparation for the subsequent parts of General Physics, but also as an introduction to Analytical and Applied Mechanics in the Engineering Course.

The work of the lecture-room aims to make the principles clearly understood, both in their nature and their application, by the following methods:

1. By experimental illustrations.

2. By their use in the explanation of these illustrations, or of well-known phenomena.

3. By their application to the solution of numerous exercises of a practical character.

Quite an extensive supply of physical apparatus, to which recent additions have been made, permit a large variety of illustrative experiments. It is not the sole or chief aim in teaching this science to store the mind with facts, but rather to develop the reasoning powers and accustom the student to trace the connection between cause and effect. After grasping a general principle established by observation and experiment, he is exercised in deducing from this general law the numerous and varied consequences which, under stated conditions, flow from it.

Where a student wishes to pursue further a special subject by experimental investigation under the direction of the instructor, opportunity is given as far as present means allow, and sometimes, with a little ingenuity in the adaptation or construction of simple apparatus, valuable results are obtained.

When desired by a sufficient number of students intending to teach Physics in public or private schools, a brief course of lectures will be given in the spring term on the methods of teaching, with special reference to such easy experiments and illustrations as may be given with apparatus which can be constructed or obtained at a very small expense. During the first two terms of the Senior Year, the subjects of Heat and Electricity occupy two hours per week. Deschanel's book is used as a basis, and all necessary amplifications are introduced into the lectures both from more extensive works and the current literature of the day.

The application of the Science of Heat to the warming and ventilation of houses, to the steam-engine and to the weather, is made by such illustrations as will tend to fix principles, as well as facts, permanently in the memory. The subject of electricity is treated with equal fullness of detail.

Throughout the whole course of Physics care is taken to show the intimate connection of the various branches of science, and to give to the novelties of the day no more than a just share of attention. The concluding part of the course is devoted to such suggestions and directions as are judged to be calculated to stimulate to and guide in original work.

V. CHEMISTRY.

Inorganic, Organic, Applied, Analytical.

(a) *Inorganic Chemistry.*

Chemistry is taught with increased fullness every year. Twenty hours per week are devoted to this branch of science, and ample time thereby given to the student to digest and assimilate each subject, presented in successive portions.

It is believed, as the result of careful inquiry, that no other institution devotes more time to instruction in Chemical Science.

Students in all the courses of the school have four terms of lectures in the various branches of Chemistry, and are required to take full notes, in order to train them in habits of accurate observation and facility of expression. These notes are taken in pencil, and are afterwards copied out in ink and handed in to the Professor for examination, criticism and correction.

During the first term, devoted to Inorganic Chemistry, the theory is presented, the construction of formulæ taught, and the chemical relations of air and water experimentally shown. The rudiments of the philosophy of gases are impressed upon the students by abundant illustrations. Especial care in taken, at this early stage of progress, to make all experiments demonstrative, so that pupils may learn to discriminate between mere hypothesis and theory based upon facts. The most approved forms of apparatus are used, when best suited to elucidate the subject, but in many cases familiar utensils are employed, for the sake of associating with them in the mind the principles learned, which will be likely to come more frequently to the recollection than would be the case if both principles and apparatus were strange.

The second term is chiefly occupied in considering the non-metallic elements, both theoretically and practically.

The third term is devoted to the metals in their purely chemical relations, preparatory to an understanding of Technical Chemistry.

(b). *Organic Chemistry.*

Organic Chemistry is taught by lectures and recitations. Beginning with an explanation of the determination of the molecular weight of organic compounds, the student is led to examine the principles of substitution valence and structure of organic compounds. Starting out from methane, the various members of the Methane (mono-carbon) series are derived. When this series has been completed, the Ethane series is taken up and gone through with in the same manner. Then follow the Butane and Propane series, and so on.

The manner of teaching and treating the subject is substantially the same as introduced by Prof. Hofmann of Berlin ; as the various substances are considered, their relations to vegetable and animal life and to agriculture are pointed out. Attention is also given to their practical applications, as in food, beverages, medicines, coloring, dyeing, soap-making, illuminating, etc. The lectures are accompanied by full experimental illustrations.

(c) *Applied Chemistry.*

The applications of Chemistry to the arts and manufactures are taught by the lectures, and illustrated by experiments so far as it is possible. The actual products are exhibited to the students, and the manufacturing processes reproduced in miniature. Attention is drawn to the scientific relations and connections between the various manufactures. The great losses by imperfect methods of manufacture and by waste-products are pointed out, and the student is taught to see the true economy of production. Illustrative of the lectures, visits are made to various manufacturing establishments, of which there are a number in and about New Brunswick, and an opportunity is given to see the manufacturing operations in actual working.

(d) *Analytical Chemistry.*

Three rooms in the Geological Hall are at present devoted to chemical analysis. These, with the annexed balance room and store-rooms, and the general lecture-room, occupy the first floor of the building.

Mention was made, in the report for 1878, of an important addition having been made to the working facilities of the department by devoting a separate room and special tables to Blowpipe Analysis. This study has, since then, been greatly developed. New desks of the latest and most approved form have been built to accommodate the continually increasing number of students. The course has been extended to the full limits of Qualitative Blowpipe Analysis, the students being able to analyze very complicated substances. An extensive stock of apparatus is kept on hand in the supply-room, so that the student is able to use the most modern appliances in his analyses.

In beginning the study of Blowpipe Analysis, the student is first taught how to blow glass, and make much of his own apparatus. He is then made familiar with the properties of the various chemical elements by performing their characteristic tests, as laid down in the text-book. Having become acquainted with the properties of the elements, he proceeds to analyze substances, or, in other words, to apply for the detection of the elements, the characteristic tests he has learned. In this manner he soon becomes expert at detecting even traces of metals, etc. The small size of the apparatus, and the ease with which analyses are performed by its aid, make it an instrument of great value to the professional man, whether he be a mining engineer desirous of examining an ore in a part of the country where only a candle is obtainable, or a physician wishing to detect, in a few minutes, the presence of arsenic, mercury, or various other metallic poisons in a suspected substance.

In all cases the student works with his note-book at his side, and must note down his work as he proceeds. The analyses are reported immediately after their completion, in printed forms, and filed for reference. The aim of these reports is manifold. Students are compelled to write down a clear and concise account of their experiments; and to be able to keep an accurate written record of their work is alone an important thing. They learn to describe natural phenomena in explicit notes—a very useful, and, for the scientific man, an absolutely indispensable acquirement. In reporting, they rigidly preserve the three great divisions of experimental science, *Experiment*, *Observation* and *Inference*. They thus become perfectly at home in practical logical deduction. Their minds are developed by their continual use of practical logical demonstration, in a way that only actual familiarity with experimental work can effect. The continual striving to express their ideas in a concise and logical form inculcates a thorough idea of system and business habits.

Determinative Mineralogy has been made a special branch of instruction, and is taken up after completion of Blowpipe Analysis. By the aid of the Blowpipe and a few chemicals, the student is soon able to determine the nature of any mineral or ore.

The examinations in Blowpipe Analysis having been successfully passed, and the student having shown, by an actual analysis of a test substance, that he is a capable analyst, the study of Qualitative Analysis is entered upon. Here a far more complicated set of apparatus and chemicals is needed. While Blowpipe Analysis can detect only a limited number of substances, Qualitative Analysis includes all the elements. The student begins in the same manner as with the blowpipe. He performs the characteristic test, and learns the manipulations. He soon enters upon actual analysis. From the most simple substances he proceeds gradually to more difficult ones, until his analyses include the most complicated and difficult mixtures. Accompanying the practical work in the Laboratory, full courses of lectures are delivered on the subject, by which the student is given a clear idea of the theory of the subject. The course concludes with examinations in the theory and practice of analysis.

Quantitative Analysis now begins. While in his former studies the student has learned how to detect the constituents of a substance, he now learns how to determine their *amount*. Here he acquires the delicacy and accuracy of the quantitative method, in which the slightest speck of matter represents a certain weight, and becomes familiar with the handling of costly instruments of precision. The student analyzes at first, compounds of known and fixed composition. As soon as he has acquired the necessary skill and manipulation, he analyzes substances of variable composition, as feldspars, limestones, clays, slags, cast-iron, steels, ores of many kinds, iron, zinc, nickel, copper, lead, tin, arsenic and antimony, German-silver, bronze, type-metal, pig-lead, paints, waters, superphosphates, guanos, milks, sal-soda, acetate of lime, sugars, bone-block, coal, soap, petroleum, flour, wine, poisons, etc.

In addition to the above subjects, a course in microscopical investigation will soon be added. A room is also being fitted up for a thorough course in practical assaying of ores, or fire analysis. In the Blowpipe, Qualitative and Quantitative Laboratories, improvements and extensions are constantly being introduced, which, with the increasing stock of apparatus and chemicals, will soon make them unsurpassed in thoroughness.

In the practical study of Analysis the student is able to apply and carry out the theoretical principles of Chemistry which he has learned in his lectures on General Chemistry. The continual practice in detecting substances by their characteristic appearances under varying conditions, and the necessity in every case of rigid experimental proof, become habits applicable to all things in actual life, and give the student a drilling and foundation in practical logical deduction and induction that are of incalculable value to him.

The student concludes his course in the Laboratory by undertaking an original experimental investigation on some point connected with theoretical or applied Chemistry. He now leaves the firm ground of known facts and methods and enters on the limitless fields of investigation and discovery. It is here that his enthusiasm is fully aroused, and his determination and energy display themselves. He discovers new facts, handles new substances, invents methods, originates expedients and learns the value and power of discovery. Failures only incite him to effort. Perseverance and determination to succeed become habitual to him.

It is in this field that the most strenuous efforts are being made toward development, for it is by this advanced teaching alone, that the student can be made to think and act for himself, place confidence in his own powers and raise himself by *original* thought and work in the profession he adopts.

The Professors in charge allow a free reference to their own books, and the College Library is open daily for consultation. The fundamental idea of the plan of instruction is to make the students independent, by teaching them not only what a routine analyst ought to know, but also the proper use of the books upon the subject. Inasmuch as many students in the regular course intend to pursue Medicine, Agriculture, &c., and hence will not be likely to make analyzing a business for themselves, they are taught also to know when and how to have analyses made, and shown how the habits of exactness and system acquired in a Laboratory are important elements of mental training.

Special students in Chemistry are, of course, required to spend much more time at work, in order to acquire greater facility. Lectures are given on the general theory of Quantitative Analysis, which explain minutely the method in use. The students are required to hand in once a week a written method, with references to the text-book, for the analysis of suppposed mixtures. These papers are criticised and discussed by the Professor. In this way the student gains a really exact and practical knowledge of the whole subject, and is never at a loss for a method in the analysis of a substance with which he has not had previous analytical experience.

Special students are required to hand in at the end of each term a thesis on some subject assigned to them for study. At the end of the summer they prepare a journal of Travel or Observation, which embodies the description of any interesting scientific objects encountered during the vacation.

We have good reason to believe that any one, on leaving the Laboratory after a full course, is competent to devote himself with success to any line of business connected with Chemistry, without further need of instruction. Medical students invariably say that their course at College has proved invaluable to them. By degrees it is becoming more evident to the public that a rapid and thorough development of the industrial resources of our country demand not only a trained class of original workers, but a spread of scientific information among the masses, in order that opportunities for employing specialists to advantage may not pass unobserved.

Practical chemists must necessarily spend most of their time in the Laboratory. The farmers and men engaged in industrial pursuits generally, ought to know what chemists can do, and ought to be able to judge pretty nearly when a chemist's aid is advantageous. The aim, then, is to teach analysis, both as a means of educational and mental discipline and as a profession, or means of earning a livelihood.

There are now twenty-one students engaged in Chemical Analysis, of whom seven are special students and three post-graduates.

VI. THE MUSEUM.

The Museum of the College occupies the second and third stories of Geological Hall, consisting of one large room, with galleries and store-rooms at the south end. The main room is ninety by forty, and twenty-five feet high. Large windows on both sides, and at the north end give an abundance of light, and so distribute it that everything is exhibited to the best advantage. On each side, under galleries, there are seven double cases, so placed as to make an alcove at each window. These are sufficiently large to admit narrow, open cases in front of each window, whenever additional space for the exhibition of specimens is demanded. These side cases contain drawers below and shelves above. The former serve for the storage of duplicates, the latter hold those on exhibition. The cases on the east side are devoted to Mineralogy and Metallurgy. Of these, one is filled with a complete collection of minerals for the use of students of mineralogy. They furnish material for the use of blowpipe analysis, for the ordinary chemical examinations, and for the illustration of the general principles of mineralogy, as crystallization, etc. Here are small suites showing degrees of hardness, electrical characters, magnetic properties, cleavage, etc. Three of the side cases are filled with larger and better examples of minerals, arranged according to the system of Dana. These can be studied, under special arrangements, by more advanced students. The collection is good and equal to the wants of elementary instruction, and for post-graduates to an advanced position. Three cases are filled with ores of the various metals—one containing iron ores, a second those of zinc (including handsome specimens from the celebrated mines of Sterling Hill and Franklin Furnace), and the third with native gold and silver, and ores of copper, lead, nickel, antimony and other metals. Among the copper compounds there is a very fine collection from the mines of Chili, South America, the gift of Miss Evans, of New Brunswick.

The west side cases hold a part of the Paleontological and Geological collections, grouped according to their age. One case contains specimens which illustrate the formation and structure of rocks. These occupy the shelves and are always to be seen by the student of Geology. Below them is a suite of five hundred specimens from Dr. Krantz, of Bonn, also for students' use. They represent by typical examples all the geological ages and periods and give a general notion of the succession of the formations of the earth. In the remaining cases the characteristic rocks and fossils of the Silurian, Devonian, Carboniferous, Triassic, Cretaceous and Tertiary and Recent ages are so arranged that the various changes in the condition of the earth and its animal and vegetable life are traced from the eozoon of the Archaic rocks to the frail shells that are to-day filling up our lakes and marshes with shell marl.

On the main floor there are five cases of ores, minerals and rocks; and two cases containing the collections of recent birds and animals.

Two of the cases contain typical specimens of the rocks, ores, marls, clays, sands and other native minerals of New Jersey, which are used in manufactures and agriculture. This collection is largely a duplicate of that exhibited by the Geological Survey at the Centennial Exposition at Philadelphia. It presents to the view of the student the varied natural resources of a State.

Two cases are filled with the Beck cabinet of minerals. In these new cases this unique and valuable collection shows to advantage, and in an appropriate and peculiar manner testifies to the diligence of Dr. Beck as a collector and mineralogist. Aside from its intrinsic importance, it will serve to call up pleasant recollections of this distinguished scientist, so long connected with the College.

A pyramidal case in the centre of the room exhibits a showy lot of quartz crystals and associated minerals from Ellenville, Ulster county, New York. The larger part of them were in the original Lange collection, which was bequeathed to the college a few years ago.

For illustrating iron working, two collections are particularly noticeable, One of these is a set of T-irons from the Trenton Iron Company ; the other a similar one of T-irons, and of rails, from the Union Iron Company, of Buffalo, New York. Many other metallurgical specimens in iron, zinc, copper, lead, nickel, silver and gold, show how these metals are obtained from their ores, and form a valuable nucleus for a metallurgical cabinet.

The few specimens of recent birds and animals occupy two large cases. This very important department is in need of large additions.

The conchological collection has been classified and beautifully arranged by George W. Tryon, of Philadelphia, in a series of flat cases running around the sides of the gallery.

The collection is large, and equal to the needs of the most advanced collegiate course. It is well filled with the most characteristic species and genera of living mollusks.

The most conspicuous object in the Museum is the skeleton of the whale which was caught in the Raritan river four years ago. The skeleton is suspended in the centre of the room, near the level of the gallery floor. It illustrates on a large scale, to the student of anatomy, the mammalian skeleton, and becomes a type in a series of such forms.

A human skeleton serves for the study of human anatomy.

The Indian antiquities and other ethnological material have been arranged in one of the cases of the main floor. The collection is small, but contains valuable relics, and shows the character of the remains of our aboriginal population.

A collection of the native woods of New Jersey has recently been placed in a new case in the south gallery. It numbers about one hundred pieces, and exhibits nearly all of the common woods found growing in our State. Some additional specimens are still much needed to make it full and representative.

The additions to the Museum during the year have not been numerous, but they indicate a steady growth, and show the interest of friends and collectors in the proper means of illustrating natural history. The collections of rocks, minerals and ores have been enriched by small suites of specimens. These additions tend to make them more serviceable in teaching geology, mineralogy and the applications of chemistry.

Of the more prominent additions the following are noteworthy :

Graphite, from Ceylon ;—the gift of William C. Fowler, Esq., of Brooklyn, and a member of the Board of Trustees of the College.

A number of stuffed specimens of New Jersey birds ;—

from Henry R. Baldwin, M. D., and Gerard Hardenbergh, Ornithologist, of New Brunswick.

Footprints in red sandstone;—from the quarry of John H. Vreeland, Whitehall, Morris county, New Jersey. There are ninety-four of these tracks on a series of sandstone blocks or slabs, whose united length is twenty feet, and their breadth six feet. The tracks are similar to those found in the Connecticut Valley sandstone, the collections from which form the celebrated ichnological cabinet of Amherst College. These tracks are of the well-known genera of Broutozooum, Grallator, and Tridentpes—extinct bird-like animals which lived in the Mesozoic Age. The distinctness of the markings, their large size and long stride attract the attention of all visitors to the Museum. They will be valuable as types in comparing the red sandstones of New Jersey and of the Connecticut Valley, and in further elucidation of the exact nature of the animals which made them.

The glass cases of the Museum are inadequate to the proper display of materials in store, and additional floor cases are wanted to fill up the main room, besides smaller cases for the galleries in which to place zoölogical and botanical specimens.

These statements indicate an increase in the attractive objects of the collection, as well as in the valuable specimens for aid in object-teaching; but the wants of the Museum are still large, since no collection is too full for the complete survey of any department of natural history, although quite adequate to the more limited requirements of the ordinary College student: but for a Scientific School and for specialists it cannot outgrow their needs.

The Museum is open every afternoon when the College is in session.

VII. THESES.

The following abstracts of a portion of the theses read before the State Board of Visitors by members of the last graduating class, are thought likely to be of interest, both on account of their subject matter and as specimens of the work done by our students:

"EXAMINATION OF SUGARS," BY W. D. SCHOONMAKER, B. S. '80.

Course in Chemistry.

After describing in detail the various methods of purifying the sugars which are in use, Mr. Schoonmaker remarks that of late, chloride of tin has been used for coagulating, instead of albumen. Considerable attention has already been drawn to this fact by chemists, and not long ago many sugars sold in the city of New York were found to contain salts of tin. Not more than a year ago a patent was taken out in Germany for the use of nitrate of zinc for the same purpose. To determine whether the sugars sold in New Brunswick also contained deleterious substances, eighty samples were purchased from the various dealers, and tested for tin and zinc. In no case, however, was a trace of either of these metals to be found.

"ANALYSIS OF 'SPIEGEL-EISEN,'" BY C. M. FREEMAN, B. S. '80.

Course in Chemistry.

As Mr. Freeman was for some time employed as chemist to the Oxford Iron Works, his description of the processes used in the manufacture of Spiegeleisen are very accurate and interesting. "Spiegeleisen" is a German word, and signifies looking-glass iron, from its peculiar lustre. It is now used to designate all pig-iron which contains enough manganese to give it the lustre peculiar to Spiegeleisen. Manganese was first introduced into the steel manufacture by Heath, who discovered that the use of one to three per cent. of it, or materials producing it, made sound cast-steel out of blistered steel from cheap British bar. It is made in a blast-furnace. The following tables show the proportions of some of the materials in various charges, used at the Spiegel furnace of the Oxford Iron Works, and were kindly furnished by Mr. Wm. H. Scranton :

	1	2	3
No. of pounds of Iron ore	500	720	260
" " Manganese ore	509	280	370
" " Limestone	200	170	370
" " Coal	1000	1000	1000
No. of tons of Spiegel in 24 hours	7	7	8
Per cent. of Maganese in Spiegel	30	28	20
Pressure of air blast	4	4	4
Temperature of blast	800	800	800

Percentage of Iron and Manganese in Iron Ore, 12 p. c., Iron, 11 p. c. of Mn.

Percentage of Iron and Manganese in Manganese Ore, 23 p. c. of Iron, 21 p. c. of Mn.

The following analyses were made of samples taken from various runs of Spiegel :

NO.	PER CENT OF MANGANESE.	NO.	PER CENT. OF MANGANESE
1	10.02.	11	9.84.
2	11.81.	12	14.30.
3	13.81.	13	15.21.
4	12.96.	14	12.48.
5	14.08.	15	12.48.
6	13.01.	16	10.32.
7	16.00.	17	14.40.
8	14.23.	18	11.61.
9	11.62.	19	10.00.
10	13.81.	20	13.63.

"EXAMINATION OF KEROSENE," BY F. A. CHAPMAN, B. S. '80,

Course in Chemistry.

After explaining the manufacture of Kerosene from Petroleum, Mr. Chapman proceeds as follows:—How it occurs that poor oils are made. Kerosene is the most important product of Petroleum. It has a burning taste and an aromatic odor. When properly refined, it is nearly colorless. Its density should be about 43 degrees beaume. At ordinary temperatures, it should extinguish a lighted match as readily as water. When heated it should not evolve vapor below 110 degrees Fahrenheit, and should not take fire below 125 degrees Fahrenheit. As the temperature of a burning lamp rarely exceeds 100 degrees Fahrenheit, it would then be perfectly safe. The crude naptha sells from two to three cents a gallon, while kerosene sells from sixteen to twenty-five cents per gallon. A great competition necessarily exists among the refiners, and thus there is a great temptation to run off the heavier parts of the naptha into the kerosene tanks,—thus getting the price of kerosene for it. They change the stream at about 63 degrees beaume, instead of at 58 degrees beaume, and the highly inflammable naptha is allowed to mix with the kerosene, rendering the whole dangerous. Dr. D. B. White found that experimenting on an oil that flashed at 113 Fahrenheit—on adding one per cent. of naptha caused it to flash at 103 Fahrenheit; ten per cent. of naptha caused it to flash at 59 Fahrenheit, and to burn at 50. Thus it is the cupidity of the refiner that leads him to mix the highly inflammable naptha with the kerosene, causing many frightful explosions.

A section in the internal revenue act of March 2, 1867, relates to the subject of dangerous kerosenes. It reads as follows:—Sec. 29, And be it further enacted that no person shall mix for sale naptha and illuminating oil or shall knowingly sell, or keep for sale, oil made from petroleum for illuminating purposes, inflammable at less temperature, or fire-test than 110 degrees Fahrenheit. And any person so doing, shall be held guilty of a misdemeanor, and on conviction by indictment, or presentment, shall be punished by a fine of not less than $100, nor more than $500, and by imprisonment for a term not less than six months, nor more than three years.

This was decided by the Supreme Court to have no effect within the several States themselves. The following States have passed laws for the regulation of the sale of petroleum oils: Maine in 1867, Vermont in 1868, Massachusetts in 1868, Pennsylvania in 1865, Rhode Island in 1871, Maryland in 1871, Ohio in 1867, Illinois in 1869, Indiana in 1863, Georgia in 1870, Michigan in 1869, Missouri in 1870, Louisiana in 1870, New York City in 1865. We see by this that New Jersey has no laws in regard to the sales of petroleum, etc.; neither have we any municipal ordinances in New Brunswick.

Thirty-five samples of oils purchased in various stores in New Brunswick, were tested by the tagliabue open tester- Out of these thirty-five, only five flashed above 110 degrees fahrenheit, and only nine above 100 degrees Fahrenheit— all the remainder being below this, or in other words, between seventy-four and seventy-five per cent. of the oils tested, were what may be called highly dangerous oils. The following are the results of the examinations:

NO.	FLASHING POINT.	BURNING POINT.	NO.	FLASHING POINT.	BURNING POINT.
1	83° f.	87° f.	18	75° f.	84° f.
2	92	114	19	82	86
3	117	127	20	100	110
4	85	99	21	119	131
5	92	114	22	83	93
6	89	114	23	74	86
7	76	85	24	98	110
8	79	91	25	78	87
9	96	105	26	79	92
10	90	96	27	131	138
11	77	86	28	114	121
12	103	114	29	78	88
13	93	97	30	75	89
14	84	94	31	79	93
15	84	89	32	80	94
16	84	88	33	109	134
17	82	87	34	118	140
35	102	117			

We see from the above results that there are but few oils sold in the city of New Brunswick which are in any way safe. Almost every day we read of the most horrible accidents occasioned from the explosions of lamps filled with what is sold as kerosene, but which might as well be called nitro-glycerine. We hear of women and children dying in unutterable tortures, of conflagrations destroying thousands of dollars of valuable property, and yet no steps seem to be taken to legally restrict the shameful and criminal cupidity which instigates our tradesmen to swindle the public and endanger the lives of our citizens, or to allot a proper punishment to those who succeed in murdering their customers.

VII. THE AGRICULTURAL DEPARTMENT AND STATE FUND.

The operations of the Agricultural Department during the past year are set forth in the accompanying report of the Professor in charge.

The amount of money received from the State Treasurer for the fiscal year ending October 31st, 1880, is six thousand nine hundred and sixty dollars ($6,960), which has been expended, as the law requires, exclusively for the salaries of Professors in the Scientific School.

Respectfully submitted,

WM. H. CAMPBELL,
President of the Board of Trustees.

REPORT ON THE AGRICULTURAL COLLEGE FARM, FOR THE YEAR 1879--'80.

BY GEORGE H. COOK.

THE WEATHER AND THE SEASONS.

Our notes of the seasons close with the month of November. The year has been marked by extremes of temperature and slight rainfall; the heat has not followed the usual or normal curve through the months, but its distribution has been quite irregular. The rainfall has been both small and unequally distributed, and the seasons were not favorable to all crops. The winter of 1879–'80 was remarkably mild and the rainfall was only three-fourths of the average for our winters. The mean temperatures and maxima and minima of the following table show the mildness of January and February as compared with the same months of previous years. The rains of those months were all comparatively light; the spring was backward and the months of March and April were cold and with frequent rains; the extremes were not so great, but the mean temperatures were below the average for these months. There were seven storms in March, when rain or snow fell in measurable quantity, and the total for that month was about 1½ inches greater than its mean rainfall. In April the increase of heat was not so marked as usual and the mean temperature was very near that ordinarily experienced in our locality. With the spring and early summer came the remarkable feature of the year—warm weather and no heavy rains. May was unusually warm and the maximum temperature of the year was reached on the 26th of that month, above that of any preceding May ever observed here. The mean temperature also exceeded the mean for years by 8 degrees. From the 20th to the 28th the daily maximum ranged from 85 to 98 degrees—a hot period, quite as long and as intense as those of our hottest summers. June, also, was marked by its high temperature and long-continued heat periods. The rainfall of the three months, April, May and June, was most abnormal, amounting to 2.68 inches, whereas the mean for these months is 12.05 inches. It was a most serious drought and there was no rain between April 29 and May 30, a period of 30 days. The result was seen in the failure of the spring growth in all crops, especially in the grass; weeds, even, were at a standstill. The light rains of June were not sufficient to do more than keep vegetation alive, and until July 5th very little of the season's growth had been made. July and August were both warm and there were frequent rains, so that the fall in these summer months exceeded the usual sum total for them by nearly 2 inches. The heat and moisture favored greatly all growing crops, and the rapidity of growth was unexampled. While the first cutting of grass was almost a complete failure, the favoring circumstances of the late summer and early autumn made the second crop much larger than that commonly cut, and much larger than the first one. The winter grain did well, also; corn grew rapidly in this hot weather, and, helped by the rains, it yielded fairly above the average. The oats crop, in consequence of the early drought, was very short in straw and light in grain. The autumn just closed has been dry and cold; the rainfall was 5.87 inches, above half that of the mean autumnal quantity. The distribution of this total was quite uniform throughout the several months of the autumn, and there were frequent rains but no severe storms. September was not marked by any extreme weather, as the range of temperature was not so wide as usual in that month, and there were no frosts. October was, on the whole, cool, although the frost made its appearance later than in many years previous. The continued warm weather throughout September and into October allowed corn and buckwheat to mature and compensate in some degree for the backward spring. The season for farm work closed suddenly on the 18th of November, the ground freezing, and wintry weather continuing steadily through the remainder of the month.

The tables below exhibit the maximum, minimum and mean monthly temperature and the rainfall at the farm for the year and for previous years:

TEMPERATURE AT NEW BRUNSWICK.

MONTHS.	MEANS.		MAXIMUM.		MINIMUM.	
	1863–'70 and 1876–'80	1880	1863–'70 and 1876–'80	1880	1863–'70 and 1876'–80	1880
	Degrees.	Degrees.	Degrees.	Degrees.	Degrees.	Degrees.
January	28.7	36.6	67	61	12	5
February	30.3	34.	67	67	10	8
March	36.9	35.6	77	72	4	19
April	48.9	47.9	81	81	27.5	30
May	58.6	66.2	98	98	37	37
June	68.3	71.9	98	97	46	49
July	75.1	76.8	101	95	56	61
August	72.1	73.	97	90	48	59
September	65.	65.	92	89	42	47
October	53.8	51.9	84	79	29	33
November	38.8	36.7	74	63	11	11
		1879		1879		1879
December	31.5	35.6	65	60	1	9

RAINFALL AT NEW BRUNSWICK.

MONTHS.	Av'ge from 1854 to 1880	1880
	Inches.	Inches.
January	3.14	1.92
February	2.95	1.45
March	3.31	4.80
April	3.80	1.56
May	3.88	0.65
June	4.02	1.47
July	4.75	7.39
August	5.09	4.08
September	3.29	1.86
October	3.44	1.93
November	3.40	2.08
		1879
December	3.73	4.14
Annual	44.80	33.33

FARM CROPS.

The farm is all under cultivation, except that occupied by the buildings, yards, roads and fish-pond. By under-draining, the whole is made dry enough to be cropped in regular succession. Of the ninety-seven and four-tenths acres in the farm, there has been this year in

	Acres.	Acres.
Wheat—Australian		.25
“ —Fultz—Near the buildings		3.85
“ “ In the south field		10.90
Rye—near the barn		3.21
Oats		6.89
Indian corn		11.44
Potatoes—south field		1.57
“ near the buildings		1.04
Turnips and truck		.73
Turnips—yellowstone (second crop)	.93	
“ rutabagas “	1.03	
Clover and timothy		41.93
Fodder corn—second crop after Wheat	4.64	
Sweet corn (second crop)	.14	
Soja beans		.78
Pettit corn		.82
Rye—southfield		1.20
Egyptian corn		.18
Pasture		5.03
Total	6.74	89.82

Wheat.—Two fields of wheat were grown this year, one of 3.85 acres, near the barn, and another of 10.90 at the south end of the farm. The crop in the smaller field was remarkably promising; it was somewhat shortened by drought, but yielded a fair crop, which is not yet threshed. The back field was very much injured by the drought, and the crop was small—only 16 bushels per acre. [For some experiments with different fertilizers on this wheat, see Experiments on Wheat, farther on.]

Black-bearded Australian wheat.—A quarter acre of good ground was sown with black-bearded Australian wheat; the seed—a half-bushel—was sent from the Department of Agriculture for trial. It was not a good sample of grain, many of the kernels being shriveled, and when sown, not more than one-third of them germinated. The scattered plants grew with broad and drooping leaves, nearly of the color of rye; the tips of some of the leaves seemed hurt by the frost, but the plants were not killed. The wheat grew vigorously in the spring and stood the drought well. It grows taller and with heavier straw than our common varieties of wheat, and its large heads and long bristling black beard give it a singular appearance. It ripens seven or eight days later than our Fultz wheat. The crop was four bushels. The grains are large, white and plump. At the Fair of the State Agricultural Society it was awarded the first premium. We are giving it another trial this year, having $1\frac{5}{100}$ acres sown with it, and it now looks very promising.

Rye.—This crop is always grown in small quantity, but on good ground, so as to have it for soiling if necessary, and if not needed for that, it becomes a grain crop, which including its straw, is quite as profitable as wheat. $4\frac{41}{100}$ acres were grown, but it is not threshed. The yield varies from 30 to 47 bushels per acre.

Oats.—This crop is grown on all the heavier ground between the corn and wheat crops. It is not a good crop to prepare the soil for wheat, as it usually diminishes the yield of the latter crop; but there is no other crop so convenient to fill the gap between the other two, and the grain is always in demand, both for market and for home use. The field contains $6\frac{89}{100}$ acres, and the yield, though much diminished by failure of rain, was a good one. The crop has not yet been threshed.

Indian Corn.—There was a field of $11\frac{44}{100}$ acres in this crop. It was put back by the dry weather in the spring; much of it was lying in the ground for some weeks after planting, but it finally sprouted, came forward, and matured a heavy crop—there being 760 bushels of shelled corn, which is $66\frac{50}{100}$ bushels per acre.

A small field of the *Pettit sugar corn* was grown, but the ears, when in the milk, are so tempting, that there is no possibility of measuring the crop. Some trials made by other farmers, however, prove that for large yield, very quick growth, as well as for its superior quality, it was not over-estimated by its originator, the late David Pettit of Salem.

The trials of fertilizers on the growth of corn are detailed further on.

Potatoes.—Two acres and $\frac{61}{100}$ of potatoes were grown. The land was heavily manured from the barn-yard, and the growth of vines was very good, but the potatoes grown did not probably measure more than 150 bushels. The location of the farm, in the suburbs of a large town, is in one respect unfortunate ;—it leaves it exposed to depredations of petty thieves. Our potato crop was much diminished by thefts of this kind. The soil, too, requires particular management to make it suitable for the growth of profitable crops of this very useful plant. We propose still further experiments with potatoes, because it should be a profitable crop for us, on account of our nearness to market, and also because it is the best crop for a rotation between corn and wheat.

Turnips.—A little more than an acre each of yellowstone and rutabaga turnips were grown, and 450 bushels were gathered. The sudden freezing of the ground has left a half acre or more still in the field.

Egyptian Corn.—A sample of what was called Egyptian corn was received from Hon. Wm. H. Yard of Trenton. It is evidently a species of Sorghum, and has been grown in Kansas very successfully. It is reported there as yielding large crops of the grain, and withstanding drought remarkably. In our experiment with it a plot of about eighteen hundredths of an acre was planted with it, in rows three feet apart and with hills a foot and a half apart. The seeds did not come up well—whether from extraordinary drought, or from bad seed is uncertain—and most of the plot was plowed up and planted with other crops. That which was left grew well and put out heads which were well loaded with seed. It was scarcely all ripened, however, when it was killed by a late frost. The seed is white and bears a close resemblance to that of common broom corn. It weighs 56 lbs. to the bushel. The heads which were tried averaged two ounces of seed each, so that if a field were planted like ours, and yielded one head to the hill it would be 21½ bushels to the acre, and if three heads were grown in each hill it would yield 64½ bushels per acre, which is not an unlikely crop, and is about what is reported of it in Kansas.

As an article of food for animals it may in some places prove valuable. Analyses show it to contain :

Water (loss at 100° C)	9.28
Ash	2.12
Albuminoids	11.25
Fiber	2.06
Fat	3.34
Carbhydrates (starch, sugar, gum)	71.95
	100.

Hay.—Nearly 42 acres of the farm was in meadow. The early drought nearly destroyed the first crop of hay—the whole amount secured being only about 60 tons, of which perhaps 24 tons was from the second crop. The heaviest loss of the year has been upon this absolutely essential farm product.

Fodder Corn.—We have continued and in fact rather increased our growth of this staple crop. We cannot, in any other way, and at the same expense of labor and manure grow the same amount of fodder that we can with this. The area grown was $4\frac{64}{100}$ acres, and if the experiment with ensilage, which is described further on, proves satisfactory, we shall increase the area given to it next year.

Pasture.—Five acres of very good ground is kept in pasture. It yields a large amount, but the field is of more importance as an exercise for our cattle than it is for the food it supplies, as most of the support of the stock is given in the yard and stables in the form of fodder, feed, and green grass, corn, etc.

STOCK.

Cows are the principal portion of the stock kept on the farm. There are 35 now in milk, and 5 now dry; besides, there is one Ayrshire bull, 1 Ayrshire bull-calf of 8 months, 5 Ayrshire heifers. The cows are kept for producing milk which is sold in part at retail to customers in New Brunswick, and in part at wholesale in Jersey City.

The milk sold in New Brunswick during the year ending Dec. 3, is 31,438 quarts, and in Jersey City 65,966 quarts.

Swine.—The Jersey red swine are still kept on the farm, and there are 10 of all ages now in stock.

Horses and Mules.—For the farm work and for delivering milk to customers and at the railroad depot, four horses and a pair of mules are kept; but no stock of this kind is raised.

EXPERIMENTS.

Experiments on wheat with Lister's superphosphate, muriate of potash and sulphate of ammonia, on three plots of four acres each:

	1	2	3
Lister's Phosphate	1600	1200	1200
Muriate of potash	----	400	----
Sulphate of ammonia	----	----	400
Yield of wheat in pounds	3396	3900	3711
Yield of wheat in bushels	56 bush. 36 lbs.	65 bush.	61 bush. 51 lbs.
Weight of measured bushel	63 lbs.	64 lbs.	64 lbs.
Weight of straw in pounds	4767	5175	5534

The *experiments* on Indian corn, with various fertilizers, have been continued this year—1880—the table marked No. 1 giving the results of the season's trial; and the one marked No. 2 gives the results with muriate of potash for the last nine years. It shows that, as far as our experiments go, this fertilizer has a specific effect on the growth and weight of the stalks. The plots tried are one-tenth of an acre each, though the results are calculated for acres. The year 1876 was remarkable for a drought which almost destroyed the corn crop.

TABLE NO. 1.

FERTILIZERS.	NUMBER OF PLOTS, AND WEIGHTS PER ACRE IN POUNDS.									
	1	2	3	4	5	6	7	8	9	10
Sulphate of Ammonia	----	300	----	----	----	200	100	200	----	-----
Superphosphate of Lime	----	----	500	----	----	300	500	500	500	-----
Muriate of Potash	----	----	----	150	----	150	150	----	----	-----
Sulphate of Potash	----	----	----	----	----	----	----	150	200	-----
Barn-yard Manure	----	----	----	----	----	----	----	----	----	32000
Corn in pounds	4720	4190	4300	4620	3900	4430	4560	4710	4750	5030
Corn in bushels	59	52	54	58	49	55	57	59	59	63
Stalks in pounds	2000	1550	1400	2200	1800	2850	2700	2600	2700	2600

TABLE NO. 2.

	MURIATE OF POTASH.			NO MANURE.	
	Pounds per acre.	Bushels of corn.	Pounds of stalks.	Bushels of corn.	Pounds of stalks.
1872	250	69	7104	69	6000
1873	250	59	4646	64	3945
1874	100	57	3787	48	3312
1875	100	100	6150	85	5500
1876	150	24	2950	26	2950
1877	150	50.2	4250	55	4100
1878	150	59	4200	40.3	2010
1879	150	63.6	4580	54.6	3210
1880	150	58	4620	57	1900

Experiments on the feeding of cows of different breeds, with specific and calculated rations, and the production of milk.

The New Jersey Agricultural Experiment Station has instituted a series of experiments on the production of milk from different breeds of cows. For this purpose the station has had a herd of mixed grade cows, and one of Ayrshires from the College Farm. The experiment also included a herd of Jerseys, from Wm. S. Taylor, of Burlington, and one of Holsteins, from James Neilson, of New Brunswick. The results of those on the College Farm are here given.

The experiment began on the 1st of November with weighing the cows, which was done shortly before noon ; and the feeding of the calculated ration was commenced. The ration consisted of clover hay. wheat straw, cotton-seed meal. brewers' grains and turnips, of which the composition is as follows :

DIGESTIBLE AND INDIGESTIBLE IN ONE HUNDRED POUNDS.

	PROTEINE.	FAT.	CARBO-HYDRATES.
Clover hay	13.06	2.50	37.71
Wheat straw	3.10	1.20	37.50
Cotton-seed meal	44.56	11.97	23.56
Brewers' grains	5.56	1.88	14.29
Turnips	1.30	0.10	10.03
DIGESTIBLE CONSTITUENTS IN ONE HUNDRED POUNDS.			
Clover hay	7.84	1.48	37.71
Wheat straw	.81	.32	37.50
Cotton-seed meal	32.97	10.89	10.84
Brewers' grains	4.72	1.50	14.29
Turnips	1.30	0.10	10.03

The ration for a cow weighing 1,000 pounds, in order to keep it in full flesh and flow of milk, must contain, of digestible elements, 2.5 pounds of proteine, 4-10 of a pound of fat, and of carbo-hydrates, 12.5 pounds; and all to be in a ration containing 24 pounds of dry matter. This ration, for 1,000 pounds, was made up of—

	PROTEINE.	FAT.	CARBO-HYDRATE.	DRY MATTER.
6 pounds of clover hay, which contain of digestible	0.47	.09	2.27	5.33
13 pounds of wheat straw	0.11	.04	4.88	11.14
20 pounds of brewers' grains	0.95	.30	2.86	3.09
20 pounds of turnips	0.26	.00	2.00	2.60
2 pounds of cotton-seed meal	0.66	.22	0.22	1.83
	2.45	.65	12.23	23.99

The total weight of six common grade cows .... 5,770 pounds
The total weight of five Ayrshire cows .... 4,477 pounds

	CLOVER. lbs.	STRAW. lbs.	GRAINS. lbs.	TURNIPS. lbs.	COTTON-SEED MEAL. lbs.
Ration for grades	35	75	115	115	11½
Ration for Ayrshires	27	58	90	90	10

These rations were fed to the cows daily, and on the 24th of November the analysis of each day's milk was begun, and was continued regularly until the 6th of December, when the cows were again weighed, and the experiment ended. The tables following give the description of the cows, their daily yield of milk, the amount of butter, cheese and sugar in each sample, and its specific gravity. Some tables in regard to the amount of nitrogen sold in the milk, the amount voided by the animals, and its value for manure, follow this.

	AYRSHIRE.					GRADE.					
NAMES OF COWS.	KICKER.	LOP HORN.	HEIFER.	SUSIE.	BEAUTY.	CAMEL.	DOMINIE.	SUTPHEN.	STRAWBERRY.	DALY.	STARFACE.
Age	15 years	13 years	3 years	7 years	5 years	7 years	7 years	9 years	6 years	4 years	6 years
Weight, Nov. 1	920	1012	785	880	880	1220	917	880	965	825	1000
Weight, Dec. 7	922	1100	760	990	849	1207	955	990	995	920	1082
Date of dropping last calf	Sept. 1, 1880.	Aug. 15, 1880.	Aug. 15, 1880.	Sept. 15, 1880.	Aug. 15, 1880.	April 15, 1880.	July 15, 1880.	Oct. 8, 1880.	Oct. 23, 1880.	June 12, 1880,	Oct. 10. 1880.
When next calf expected	Not with calf	June 28, 1881.	June 20, 1881.		July 1, 1881.	April 1, 1881.	Aug. 1, 1881.		Aug. 29, 1881.	July 13, 1881.	
	YIELD OF MILK.					YIELD OF MILK.					
	lbs oz	lbs oz	lbs oz	lbs oz	lbs oz	lbs oz	lbs oz	lbs oz	lbs oz	lbs oz	lbs oz
November 24	20.0	27.0	17.8	24.0	23.0	19.0	23.8	27.4	26.0	15.8	24.8
" 25	20.8	25.0	16.0	26.4	23.0	21.8	24.0	25.8	25.0	15.0	24.0
" 26	20.8	26.8	17.0	23.0	21.0	22.4	25.0	27.0	26.0	15.8	25.0
" 27	20.0	26.0	17.0	24.0	20.0	21.8	23.0	26.8	25.8	16.8	23.8
" 28	20.8	25.0	16.0	24.0	21.0	21.8	22.0	25.8	28.8	16.8	25.8
" 29	19.8	27.0	17.8	24.8	20.8	20.0	22.0	25.8	26.8	15.8	23.0
" 30	20.0	27.0	16.8	26.0	21.0	20.0	23.0	25.0	26.8	17.0	26.0
December 1	20.8	27.0	16.8	26.8	21.8	20.0	23.0	24.0	26.12	16.0	22.8
" 2	20.8	25.0	15.8	24.0	20.0	19.0	21.0	24.0	23.0	15.0	24.8
" 3	21.0	26.8	20.0	24.8	20.0	18.8	24.8	22.8	26.8	16.8	23.0
" 4	21.8	27.0	15.8	24.0	19.0	19.8	26.0	24.0	27.0	18.0	23.12
" 5	21.0	26.8	16.8	27.0	17.0	21.0	26.0	25.0	30.0	17.0	23.8
" 6	23.0	28.0	18.0	27.0	18.0	17.8	23.0	25.8	24.8	17.8	23.12
	268.8	343.8	219.8	324.12	265.4	261.4	306.0	327.4	341.4	211.8	311.8

ANALYSES OF MILK.

SIX GRADE COWS—COLLEGE FARM.

MONTH.		Daily yield of milk expressed in pounds.*		Specific Gravity.	Loss at 100 degrees C.	Total solids gravimetical.	Butter.	Proteine.	Sugar.	Ash, by difference.
		lbs.	oz.							
November	24	135	12	1.0330	86.53	13.47	4.39	3.40	4.81	.87
"	25	135	..	1.0326	86.54	13.46	4.38	3.40	4.70	.98
"	26	140	12	1.0326	86.33	13.67	4.50	3.40	4.76	1.00
"	27	136	8	1.0330	86.47	13.53	4.57	3.40	4.79	.81
"	28	136	8	1.0335	86.36	13.64	4.57	3.39	4.70	.98
"	29	132	8	1.0335	85.97	14.03	4.74	3.39	4.91	.99
"	30	137	8	1.0320	86.53	13.47	4.58	3.39	4.58	.92
December	1	132	4	1.0330	86.33	13.67	4.68	3.35	4.88	.76
"	2	126	8	1.0330	86.08	13.92	4.61	3.35	4.99	.97
"	3	131	8	1.0320	86.56	13.44	4.42	3.34	4.99	.69
"	4	138	4	1.0320	86.69	13.31	4.27	3.22	4.88	.94
"	5	142	..	1.0334	87.00	13.00	4.07	3.13	4.80	1.00
							4.58			
"	6	130	12	1.0320	86.13	13.87	4.28	3.31	4.94	1.04
Totals		1755	12	----	----	176.48	58.36	43.47	62.73	----
Daily average		135	..	----	86.43	13.57	4.49	3.34	4.82	.92
Daily average of each cow		22	8	----	----	----	----	----	----	----

* Two pounds are equal to one quart, nearly.

FIVE AYRSHIRE COWS—COLLEGE FARM.

MONTH.		Daily yield of milk expressed in pounds.*		Specific gravity.	Loss at 100 degrees, C.	Total solids gravimetical.	Butter.	Proteine.	Sugar.	Ash, by difference.
November	24	111	8	1.0310	87.08	12.92	4.23	3.23	4.62	.84
"	25	110	12	1.0310	87.08	12.92	4.29	3.15	4.60	.88
"	26	108	..	1.0310	87.14	12.86	4.36	3.15	4.58	.77
"	27	105	..	1.0310	87.18	12.82	4.30	3.23	4.62	.67
"	28	106	8	1.0310	87.17	12.83	4.34	3.25	4.60	.64
"	29	109	..	1.0310	87.22	12.78	4.33	3.25	4.60	.60
"	30	110	8	1.0308	87.08	12.92	4.31	3.21	4.58	.82
December	1	112	..	1.0305	87.07	12.93	4.59	3.20	4.58	.56
"	2	105	..	1.0300	87.32	12.68	4.27	3.19	4.73	.59
"	3	112	..	1.0310	87.13	12.87	4.39	3.22	4.59	.67
"	4	107	..	1.0310	87.07	12.93	4.36	3.18	4.65	.74
"	5	108	..	1.0310	87.46	12.54	4.14	3.04	4.50	.86
"	6	114	..	1.0310	86.84	13.16	4.36	3.31	4.65	.84
Totals		1419	4	----	----	167.14	56.27	41.61	59.90	--
Daily average		109	..	----	87.15	12.85	4.33	3.20	4.60	.72
Daily average of each cow		21	12	----	----	----	----	----	----	----

* Two pounds are equal to one quart, nearly.

COST OF RATIONS.

35 lbs.	75 lbs.	115 lbs.	115 lbs.	11½ lbs.	
Clover hay	Wheat straw.	Brewers' grains.	Turnips.	Cotton-seed meal.	Total.
26c.	26c.	23c.	19c.	15c.	$1.09

The cost of a ration made from clover hay and Indian meal, of equal nutritive value for the cows, would cost from $1.75 to $2.00.

COST OF RATION FOR ONE QUART OF MILK.

Clover hay per ton, $15; wheat straw, $7.00; brewers' grains per bushel, 8c.; turnips (60 pounds), 10c.; cotton-seed meal per ton, $26; 13 days' rations at $1.09, $14.17: and gave 1,755 pounds of milk; ration for 1 pound of milk costs $\frac{81}{100}$ of 1 cent and a quart costs 1 $\frac{62}{100}$.

Amount of nitrogen in the daily ration is 3$\frac{18}{100}$ pounds, and in 13 days is 41 $\frac{34}{100}$ pounds. Of this 9 $\frac{47}{100}$ pounds is sold in the milk, and that retained in the flesh gained by the cows is 4$\frac{52}{100}$ pounds, leaving 27$\frac{35}{100}$ pounds of nitrogen in the manure of the six cows for 13 days, which, at 20c. per pound, is worth $\$5\frac{57}{100}$.

These experiments have been conducted with great care and labor, by Mr. Arthur T. Neale, the chemist of the Agricultural Experiment Station. The topics they touch upon open wide fields for investigation, which it is hoped can be prosecuted to profitable ends.

ENSILAGE.

An experiment in preserving green fodder corn, by cutting it up into short pieces, packing it down in a pit and protecting it from the air, has been begun on the farm—a tight bin 8 feet wide, 10 feet deep and 12 feet long has been built in the cellar of the barn. It was built of double boards, with paper between them. Thirteen and one-half tons of the cut fodder was put into it and covered with boards and a heavy load of earth. It was put in about October 1st, and was opened on the 16th of December. It had not given off any smell during the time. Now that it is opened, a smell something like that of vinegar is perceived, but the fodder is still green, and the cows eat it clean. It is not time to make any definite conclusions, as its effects on the cattle are yet to be noted. It is to be analyzed and its analysis to be compared with that of the same corn-fodder which has been cured in the usual way in the field. But it is quite certain that it affords a way of preserving green fodder for winter use, so that it can all be eaten, and nothing left to waste.

RYE—ITS TILLERING.

Some remarkable examples of the number of shoots which come from single grains of rye have been noticed this year.

One, in an old field near Jamesburg, was counted, and found to have fifty-four stems with heads. But Mr. Joseph Lodge, of Bonhamtown, sent two samples from near that place, one of which had fifty-one, and the other had seventy-six heads. They were pulled up before they were quite ripe, so that the grain in them could not be measured. Common heads of rye, however, average about thirty grains to the head, at which rate the larger growth would have yielded 2,280 grains. A bushel of rye of medium-sized grains contains 1,349,376 grains. The result is a curious one, and is worthy of consideration, in view of the fact that in practice we do not expect to get more than fifteen grains from each one sown, and of course we lose by far the larger part of all that we sow.

COURSES OF STUDY.

Four distinct courses of study are included in the schedule which follows:

I. A Course in Civil Engineering and Mechanics.

II. A Course in Chemistry and Agriculture.

III. A Special Course in Chemistry.

IV. A Special Course in Agriculture.

During the first and second years the studies of the two full courses are the same, and are designed to furnish a suitable introduction to the pursuit of the higher branches in either.

During the last two years the subjects of Higher Mathematics, Mechanics and Engineering, in the Engineering Course, are replaced by Analytical Chemistry, practice in the Laboratory, and Agriculture in the other. The remaining subjects are pursued by the students of both courses together.

The course of study for the first two years in this Department is arranged so as to be complete in itself. It is especially designed to meet the wants of those who cannot take the entire four years' course, but who desire to fit themselves as Land Surveyors. Students leaving at this period of the course, receive from the Faculty a certificate of their attainments.

Students in this Department have daily practice in Draughting, with exercises and problems in Geometrical Constructions, in Descriptive Geometry, Topographical, Mechanical and Architectural Drawing, and in Graphical Statics. Several students who had acquired sufficient skill obtained positions as draughtsmen in various offices in the city during their course.

Special Students are received, and allowed to take any part of the above course, provided their previous education is sufficient; and particular provision is made for them, especially in the Laboratory, in Mathematics, Surveying and Draughting.

The Special Courses in Chemistry and Agriculture occupy two years. The Laboratory is open from 9 A. M. until 5 P. M.

Students are instructed in Blowpipe Analysis; Determinative Mineralogy; Analysis of Ores, Minerals, Coals, Waters, Technological Products, etc.; Assaying; Analysis of Soils, Fertilizers, Agricultural Products and Foods; Volumetric Analysis of Gases; Detection of Poisons; Analysis of Urine and Animal Products and Microscopical examinations. The course of study depends to some extent upon the student's future pursuit in life.

MILITARY TACTICS.—In accordance with the requirements of the Law, provision is made in this Department for the study of Military Tactics.

Special provision is also made for students who desire, after completing the regular course of study, to take post-graduate studies.

In connection with the instruction in Agriculture in this Department, the Trustees maintain an extensive model farm, designed to illustrate the principles of agriculture, and also to test by experiment the value of different systems. It is under the charge of the Professor of Agriculture, and *every Wednesday* during term time will be devoted to giving, upon the farm, explanations of the experiments and their results, to the students in agriculture, as well as to any farmers who may desire to avail themselves of this privilege.

COURSES OF STUDY.

FRESHMAN YEAR.

Exercises during the year in Composition and Declamation.
Bible Class Sabbath morning.

FIRST TERM.

1. French. 2. Mathematics—Algebra, from Series. 3. Natural History—Dalton's Physiology; Lectures. 4. Rhetoric—D. J. Hill; Lectures. 5. Draughting—Practical Geometry, Plane.

SECOND TERM.

1. French. 2. Mathematics—Solid Geometry. 3. Natural History—Zoölogy; Lectures. 4. Elocution—Lectures. 5. English Literature—Hadley's History of the English Language; Morley's English Literature. 6. Draughting—Coloring, Topographical Signs, &c.

THIRD TERM.

1. French. 2. Mathematics—Trigonometry, Plane and Spherical. 3. Natural History—Gray's Botany; Lectures. 4. English Literature—Morley's English Literature, and Lounsbury's Edition of Chaucer's Parlament of Foules; Lectures. 5. Draughting—Mapping, with Sections, &c.

SOPHOMORE YEAR.

Exercises during the year in Composition and Declamation.
Bible Class Sabbath morning.

FIRST TERM.

1. Surveying—Murray's Manuel; Field Exercises and Mapping. 2. Descriptive Geometry—Church. 3. Chemistry—Lectures. 4. Mental Philosophy—Porter's Elements

of Intellectual Philosophy. 5. History—Freeman's Outlines. 6. Draughting—Practical Geometry, solid.

SECOND TERM.

1. Descriptive Geometry—Church ; Construction of Problems ; Navigation and Railroad Curves. 2. Chemistry—Lectures. 3. Mental Philosophy—Porter' Elements of Intellectual Philosophy. 4. History—Freeman's Outlines. 5 Draughting—Intersection of Surfaces, &c.

THIRD TERM.

1. Leveling and Railroad Curves—Henck's Field Book ; Field Practice and Plotting. 2. Shades, Shadows and Perspective—Church ; Construction of Problems. 3. Chemistry—Lectures. 4. Mental Philosophy—Porter's Elements of Intellectual Philosophy. 5. History—Creasy's Constitutional History of England. 6. Draughting—Linear Perspective, &c.

SENIOR YEAR.

Exercises during the year in Composition and Original Declamation. Bible Class Sabbath morning.

COURSE IN CIVIL ENGINEERING AND MECHANICS.

FIRST TERM.

1. Mechanics—Tate or Wood. 2. Engineering—Mahan. 3. Organic Chemistry. 4. Moral Philosophy — Calderwood's Hand-book. 5. Draughting — Machinery and Architecture. 6. Chemical Physics.

COURSE IN CHEMISTRY AND AGRICULTURE.

FIRST TERM.

1. Applied Chemistry. 2. Principles of Agriculture—Lectures. 3. Laboratory Practice, and Lectures on the Theory of Quantitative Analysis. 4. Moral Philosophy—Calderwood's Hand-book. 5. Draughting. 6. Organic Chemistry. 7. Chemical Physics.

SECOND TERM.

1. Engineering—Mahan. 2. Mechanics—Tate or Wood; Bridge Building, Wood; Indeterminate Analysis. 3. Organic Chemistry. 4. Moral Philosophy—Butler's Analogy. 5. Draughting—Engineering. 6. Chemical Physics.

THIRD TERM.

1. Engineering—Bridge Building and Railway Practice; Geodesy. 2. Geology—Lectures. 3. Moral Philosophy—Butler's Analogy. 4. Draughting—Theses.

SECOND TERM.

1. Agriculture—Its Methods and Products. 2. Organic Chemistry. 3. Laboratory Practice and Lectures on the Theory of Analysis. 4. Moral Philosophy — Butler's Analogy. 5. Draughting. 6. Chemical Physics.

THIRD TERM.

1. Agriculture—Animal Physiology; Care and Management of Domestic Animals. 2. Geology—Lectures. 3. Moral Philosophy—Butler's Analogy. 4. Draughting. 5. Laboratory Practice and Lectures on the Theory of Analysis. 6. Theses. 7. Mineralogy.

JUNIOR YEAR.

Exercises during the year in Composition and Original Declamation. Bible Class Sabbath morning.

Course in Civil Engineering and Mechanics.

FIRST TERM.

1. German. 2. Analytical Geometry—Olney. 3. Natural Philosophy—Deschanel. 4. Political Economy — Bowen and Perry. 5. Draughting—Lettering, &c.

Course in Chemistry and Agriculture.

FIRST TERM.

1. German. 2. Analytical Chemistry—Text book, with Laboratory Practice and Lectures on the Theory of Analysis. 3. Agriculture—Lectures at the farm. 4. Natural Philosophy—Deschanel. 5. Political Economy—Bowen and Perry. 6. Draughting—Lettering, &c.

SECOND TERM.

1. German. 2. Analytical Geometry, completed ; Differential and Integral Calculus—Olney. 3. Natural Philosophy—Deschanel. 4. Constitutional History of the United States—Text-book (Andrews) and Lectures. 5. Draughting—Shading, &c.

THIRD TERM.

1. German. 2. Calculus, completed. 3. Astronomy. 4. History of Civilization—Guizot. 5. Drafting—Constructions.

SECOND TERM.

1. German. 2. Analytical Chemistry—Text book, with Laboratory Practice and Lectures on the Theory of Analysis. 3. Agriculture—Lectures. 4. Natural Philosophy—Deschanel. 5. Constitutional History of the United States—Text-book (Andrews), and Lectures. 7. Draughting—Shading, &c.

THIRD TERM.

1. German. 2. Analytical Chemistry—Text-book, with Laboratory Practice and Lectures on the Theory of Analysis. 3. Agriculture—Vegetable Physiology. 4. History of Civilization—Guizot. 5. Draughting—Constructions.

SPECIAL COURSE IN CHEMISTRY.

FIRST YEAR.

FIRST TERM.

1. Inorganic Chemistry. 2. Blowpipe Analysis. 3. Qualitative Analysis. 4. French. 5. Theses.

SECOND TERM.

1. Inorganic Chemistry. 2. Qualitative Analysis. 3. Mineralogy. 4. Crystalography. 5. Chemical Physics. 6. French.

THIRD TERM.

1. Inorganic Chemistry. 2. Quantitative Analysis. 3. Stoichiometry. 4. French. 5. Theses. Journal of Travel or Observation.

SECOND YEAR.

FIRST TERM.

1. Organic Chemistry. 2. Applied Chemistry. 3. Chemical Physics. 4. Quantitative Analysis. 5. German. 6. Theses.

SECOND TERM.

1. Organic Chemistry. 2. Applied Chemistry. 3. Chemical Physics. 4. Quantitive Analysis. 5. German. 6. Animal Chemistry. 7. Theses.

THIRD TERM.

1. Applied Chemistry. 2. Chemical Physics. 3. Geology. 4. Assaying. 5. German. 6. Agricultural Chemistry. 7. Theses.

SPECIAL COURSE IN AGRICULTURE.

FIRST YEAR.

FIRST TERM.

1. Algebra. 2. Geometrical Problems. 3. Inorganic Chemistry. 4. Physiology and Zoölogy.

SECOND TERM.

1. Geometry. 2. Coloring and Topographical Drawing. 3. Analytical Chemistry. 4. Mineralogy. 5. Book-Keeping.

THIRD TERM.

1. Trigonometry. 2. Mapping. 3. Analytical Chemistry. 4. Botany. 5. Farm Accounts.

SECOND YEAR.

FIRST TERM.

1. Surveying. 2. Projections. 3. Natural Philosophy. 4. Study of Domestic Animals. 5. Systematic Agriculture.

SECOND TERM.

1. Navigation and Nautical Astronomy. 2. Architectural Drawing. 3. Physics. 4. Geology. 5. How Crops Grow.

THIRD TERM.

1. Leveling and Road Making. 2. Machine Drawing. 3. Meteorology. 4. Botany. 5. How Crops Feed.

Composition and Declamation throughout the whole course.

The hours of lectures or recitations are four each day, besides work in the Chemical Laboratory.

Students who pass their regular examination in the above subjects, will, at the close of their course, receive certificates of their attainments. And at the end of two or more years further, if they shall have pursued practical agriculture on a farm, and shall then pass satisfactory examinations in prescribed subjects on Agricultural Principles and Practice before a Board of Examiners of the Scientific School, they shall receive Diplomas in Agriculture.

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